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Fatigue management in the workplace

ABSTRACT

Workers' fatigue is a significant problem in modern industry, largely because of high demand jobs, long duty periods, disruption of circadian rhythms, and accumulative sleep debt that are common in many industries. Fatigue is the end result of integration of multiple factors such as time awake, time of day, and workload. Then, the full understanding of circadian biologic clock, dynamics of transient and cumulative sleep loss, and recovery is required for effective management of workplace fatigue. It can be more investigated in a new field of sleep medicine called occupational sleep medicine. Occupational sleep medicine is concerned with maintaining best productivity and safety in the industrial settings. The fatigue risk management system (FRMS) is a comprehensive approach that is based on applying scientific evidence of sleep knowledge to manage workers fatigue. It is developing rapidly in the highly safety demand jobs; especially truck drivers, pilots, and power plant workers. The objective of this review is to explain about fatigue in the workplace with emphasis on its association work performance and errors/accidents. Also, we discussed about different methods of fatigue measurement and management.

Keywords: Fatigue management, safety, workplace

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Fatigue is a work place hazard and can be associated with safety and health of the worker. It affects the health and safety of both the employee and his/her colleagues. The term "fatigue" had a widespread usage in occupational medicine. Fatigue is a complex phenomenon that can be attributed to many factors. Therefore, it is difficult to find a comprehensive definition with universally agreement for it. Also, there are other terms such as drowsiness and sleepiness that often used in literature interchangeably instead of fatigue. One of them is an aspect of fatigue, and then it is easier to define them compared with fatigue. The first step in the approach to the fatigue complains is to distinguish between sleepiness and fatigue. Distinguishing between them can be difficult even for expert clinician, but multiple sleep latency testing can be helpful.[1]

It is noticeable that sleepiness and fatigue can exist in the same time as a consequence of sleep deprivation in workers. Sleepiness reflects the neurobiological need to sleep that induces sleep drives of an individual to fall asleep. After working at night or a night without sleep, we have higher levels of sleepiness. While after forceful physical exercise during the day time we have fatigue, but we cannot sleep easily. Fatigue usually refers to impairment in task performance. Also, fatigue has a psychological aspect that means not having enough energy to do work and experience subject reluctance to continue a task.[2]

Thus, a fatigue person receives a signal from his body that the ongoing activity either physical activity or mental activity should be ended. It is necessary to mention that there are difference between sleepiness and fatigue in terms of definition and causes, but the effects of both of them could be same. Essentially, their effects include a decrease in capacity for doing mental and physical performances.

There are many different definition of fatigue, but generally fatigue is: "A state of feeling tired, weary, or sleepy that results from prolonged mental and physical work, extended periods of anxiety, exposure to harsh environment, or loss of sleep". At the other definition, according to the Health Safety Executive: "Fatigue is a result of prolonged mental or physical exertion; it can affect people's performance and impair their mental alertness, which leads to dangerous

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errors."[3] The objective of this review is to illustrate concept of fatigue and its adverse effects in the workplace. The paper then continues by discussing about different strategies for fatigue measurement. Finally, we discuss different countermeasures for fatigue management in the workplace.

EPIDEMIOLOGY

The complaint of fatigue is high in general population in range of 18.3–27%.[4] The higher prevalence of fatigue has been reported in many operational settings that induce health and safety problems. According to the study results, fatigue is a common reason for employees to consult with a general physician at industrial settings. The prevalence rates of fatigue in industries depending on the instruments used have been reported between 7 and 45%.[5]

At the survey among short haul commercial pilots severe fatigue and be worsen of it, are reported at 57 and 81% of respondents, respectively. Another studies show that physicians and nurses with accumulation of sleep loss and fatigue during successive work shifts have a rise in accident rates and errors.[6-8] Also, about 20–30% of road accidents and 5–15% of all fatal road accidents involve driver fatigue.[9]

ASSOCIATION OF FATIGUE WITH WORK OUTPUT, ERROR, AND ACCIDENTS

Fatigue affects everyone regardless of skill, knowledge, and training. It has influences directly on many people's physical and mental abilities needed to carry out even simple task. The most important effects of fatigue including decreased task motivation, longer reaction time, reduction of alertness, impaired concentration, poorer psychometric coordination, problems in memory and information processing, and poor judgment. It is estimated that fatigue workers in workplace is costing more than 18 billion $ a year in US.[10]

Also, a fatigue people have a poor communication with surrounding environment and more quickly becomes angry towards other people. Therefore, a fatigue worker is potentially dangerous to themselves and others, and the highest rate of catastrophic incidents is usually found among fatigue shift workers. For example, some of the most serious accidents in recent 3decades have been attributed to the shift worker's fatigue. The world's worst nuclear power accident occurred at Chernobyl on April 25, 1986 at 1:23 am. The accidents at Three Mile Island, the oil spill from the Exxon Valdez, all occurred between midnight and 6 am. These accidents along with a great deal of transportation accidents in roads were raised from humans' fatigue.[1]

CAUSES OF FATIGUE IN THE WORKPLACE

There are many factors at both; in the workplace and out of workplace which can influence fatigue levels. The most important cause of fatigue is the lack of restorative sleep. In addition, fatigue can be induced from a combination of interrelated factors. Work load refers to the amount of work that is assigned to an employee to do. It induces fatigue in the workplace and can be assessed in three category including physical load, environmental load, and mental load. The following diagram shows a comprehensive view of the work-related causes of fatigue [Figure 1].[11]

FATIGUE MEASUREMENT

Fatigue is a problem that cannot be easily measured in the workplace. The majority of workers are reluctant to express their feeling of fatigue. It is especially true in an incident investigation. Also, there is no single instrument as a gold standard for fatigue measurement, because of the widespread effects of fatigue on human skills, definitional difficulties of fatigue, and multiple causes of fatigue. However, as a first step to manage fatigue in workplace, we have to identify and measure fatigue and their causes in industrial settings.

There are great deals of instruments available on this subject including books, articles, guidelines, standard questionnaires, and more. Some of these instruments are inconclusive and sometimes contradict each other. It is necessary to recognize most accurate and industry-appropriate material for each work place. In addition, acquisition of sufficient knowledge about advantages and disadvantages of each instrument in work place is important.[12]

In this case, employees and employers can identify and manage fatigue in the workplace, identify useful methods for avoiding fatigue or reducing its probability, consider a number of coping strategies for fighting fatigue, and perform accident investigations after happening

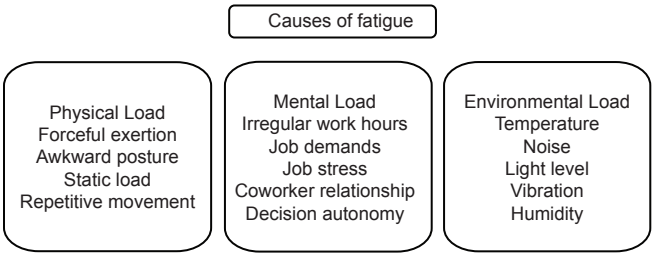

Figure 1: Different causes of fatigue in the workplace

fatigue-induced problems. The type of instrument for fatigue measurement is depending on the decision that must be made by the organization. Measurement can determine one dimension of fatigue, usually severity of fatigue, or multiple dimensions. Additional measurements can be used to gather more information about fatigue type or impact or about phenomena conceptually related to fatigue.[13]

The most important dimension that typically used in simple one-dimensional scales is severity of fatigue. Variety of one-dimensional scales used for research or clinical purposes. The most common scales are five-point verbal rating scales (from none to very severe fatigue) and visual analog scale (from no fatigue to worst possible fatigue in 10 cm VAS).[14]

Another type of subjective quantification of fatigue is multidimensional assessment of fatigue (MAF). This instrument rates the degree to which a person has experienced fatigue 1 week ago and its severity. The more comprehensive scale for quantification of fatigue is Piper Fatigue Scale. It has additional items to measure interference of fatigue with activities of daily living and timing of fatigue.[6]

The second way to survey fatigue is investigation of correlates of fatigue such as sleep and depression. They are typically used to detect whether a worker is suffering from effects of fatigue. The most common application of them is as part of an assessment of fatigue for academic researches. The Epworth Sleepiness Scale (ESS) is a self-rating method to rank either how sleepy a person generally is. Therefore, it shows how a person is prone falling asleep during the daytime working hours. The ESS is composed of eight items assessing how likely a person will doze off in different situation including cinema, talking to someone, immediately after lunch, and Perceived severity of sleepiness in each item is rated on a 0–4 scale and a total score which ranges from 0 to 24 obtains from summing the items ratings. Generally, a total of 10 points or higher is considered as excessive sleepiness.[7]

Another instrument that is used for fatigue research is the Horne–Ostberg questionnaire (HOQ). The HOQ contains 19 questions aimed at determining when respondents would prefer to wake up or start sleep, rather than when he/she actually does. It detects an individual as either a morning person (Lark type), or an evening person (Owl type), or as having no preference (indifferent type). Its scales can be used to assign suitable person to different shift design.[15]

There are more objective devices that are used in fatigue measurement investigations. Laboratory testing of performance measures very specific aspects of performance such as reaction time, vigilance, and short-term memory. They act as indicators of worker's capacity to carry out their duties. The short-time version of "Psychomotor Vigilance Task" has been widely used for this purpose.[16]

Sleep problems is a key factor for fatigue induction, and thus results from sleep monitoring is another way to fatigue measurement. Sleep questionnaires, sleep diaries, actigraphy, and polysomnography can be used at both of the laboratory studies and workplace settings to investigate sleep quantity and quality. These studies are more suitable in situations that there is a suspicious worker suffering from a kind of sleep disorder.[17]

Another correlates of fatigue such as distress and depression may be used to assess when measuring fatigue. The Symptom Distress Scale (SDS) 13-items questionnaire is about distress symptoms such as pain, nausea, tiredness, etc., that are rated on a five-point Likert scale. The results of SDS reflect degrees of distress ranging from the lack of symptom until being at its worst condition.[18]

Depression is the other important correlate requiring some consideration in any study of fatigue. Fatigue is a well-known symptom of depression, it is important to have a standard measure of depression in order to assess fatigue. The complete version and Short Form of the Profile of Mood States consisting of six subscales including depression, tension, anger, confusion, fatigue, and vigor.[19]

The last contributing factor for assessing and measuring fatigue is the biological parameters. There are no clear biological markers for identifying fatigue. Also, it is difficult to monitor them during the work hours. But, measuring daily rhythms of core body temperature and levels of melatonin hormone has been used for monitoring the circadian body clock cycle, especially in laboratory investigations.[6,12-14]

All of the instruments mentioned above are usable at both of the workplace setting and general population. There are other techniques that can be used to assess and quantify fatigue physiologically. The physiologic measurements include energy expenditure, cardiovascular response, reaction and response time, skin temperature, and blink rates. For example, researches showed that blinking was related closely to mental tension. There is an indirect relation between blinking rate and task difficulty. As a task becomes more difficult, the rates of blinking become slower. Also, increasing systolic and diastolic blood pressure during hard static work can induce decrease in the heart rate through the carotid baroreceptor mechanism.[6,12-14]

FATIGUE MANAGEMENT

As mentioned above, fatigue can have multiple causes in the workplaces. Therefore, there is no comprehensive single countermeasure to eliminate fatigue from industrial settings. It is necessary to consider ranges of strategies to address the different types and causes of fatigue. For practical purposes, multiple divisions have been considered for fatigue countermeasures of activities. In the first one, fatigue countermeasures have been divided into two categories: (a) Preventive strategies that are used before working hours and during rest times, and (b) operational strategies that are used during the job (driving, refinery operation, computer terminal at control room, etc.).[4]

Since circadian disruption is the most important cause of fatigue, preventive strategies are designed to decrease the impact of circadian disruption and sleep loss on performance and alertness during the job. There are varieties of different methods in this strategy. The majority of them temporarily relieve fatigue symptoms. Then help the workers get their job as safely and efficiently as possible. Some of these strategies including minimize sleep loss, naps during night shifts, education of good sleeping habits to workers, stimulators, and acceleration in circadian adaptation to different shift types.[2,3,5,9,10]

Minimize sleep loss

Promoting quantity and quality sleep is an essential factor for ensuring optimal performance during work time. Generally speaking, majority of people need about 8 h of sleep per day to preserve full alertness. A few people can function well on sleep less than 8 h. Obtaining only 6 h for an individual who requires 8 h of sleep result to sleep-deprivation by 2h. It is recommended to have adequate resting time before a shift. The data showed that risk of fatigue increased exponentially at the 12-h shifts and early start shifts. It is necessary to avoid overtime on 12-h shifts and provide at least a 24-h break between shifts.[20]

Naps during night shifts

Napping as a fatigue countermeasure has been found to be effective for shift workers. Many researches showed that short naps improve both of the mood and performance. Also, it was found that a 30 min nap in subjects with normal sleep and who had a night of restricted sleep decrease sleepiness and increase subjective alertness. The positive effects of naps depending on many issues including timing of the nap, nap length, and severity of sleep inertia following a nap.

Field studies have shown that even a brief sleep episode can improve performance for several hours following the nap. The longer and later napping is better to sustain early morning performance and improve workplace safety. However, if there is a limitation for napping time, it is suggested that approximately 90–120 min of a single sleep cycle (falling asleep to rapid eye movement (REM) sleep) is the most effective. Also, naps with 30 min in length or less provide measurable improvement in alertness and performance and decrease fatigue immediately upon waking.[4,8,20]

Good sleeping habits

There are specific strategies that can help improve each sleep opportunity, and some of them include: When possible keep a regular sleep/wake schedule to avoid circadian disruption; reserve the bedroom for sleep and not for work, if possible; develop a comforting presleep routine such as listening radio; avoid frequent naps during the day; get out of bed if there is a trouble with falling asleep; do not use caffeine, alcohol, and cigarettes right before bedtime; and making bedroom quiet, totally dark, and comfortable (the ideal temperature for a bedroom is about 18–24°C).[4,8,20,21]

Circadian adaptation

The circadian rhythms in shift workers do not usually phase shift to adapt totally to sleeping during the day and working at night. This situation results in poor performance, fatigue, and reduced alertness during working time. Appropriate timed exposure to bright light and administration of exogenous melatonin help to produce circadian adaptation to night work. Bright light exposure in the evening delay the circadian phase to a later position, whereas exposure to bright light in the morning advances the circadian phase to an earlier position. Also, bright light have an immediate alerting effects on mood and performance. Melatonin is an important synchronizing agent for the circadian system. Exogenous administration of melatonin has phase shifting properties. Some studies have shown that a single or repeated daily treatment with melatonin can change the timing of some rhythms such as sleep, core body temperature, and secretion rhythms of endogenous melatonin and cortisol. Administration of melatonin in the evening and the first half of the night will advance the phase of circadian rhythms, whereas, melatonin administration during the morning or at the second half of the night will phase delay.[22,23]

Stimulators

When other nonpharmacologic approaches to fatigue management become impractical or ineffective, alert-enhancing medications should be considered. They help workers sustain alert during extended work shift when adequate restorative sleep is not possible. Stimulants to combat the effects of fatigue have been used in many

industries. The most widely used drug in this group includes modafinil, amphetamines, and caffeine.[8,20,21]

Variety of methods available to overcome fatigue during operation is less than the above mentioned preventive strategies. In most of the industrial settings, especially in high safety demanding work, it is a mandatory restriction that workers must remain in their work place throughout the working hours. So, there is no possibility for using different methods of operational fatigue countermeasures. Also, it is necessary to keep in mind that operational countermeasures do not address the underlying physiological causes of fatigue. They can help to temporarily enhance alertness and performance by masking fatigue, but their effects last only for a short time. Some of strategies that located in this category include social interaction and conversation with coworkers, physical activity, and caffeine consumption.[4,11,12]

It is likely that the traditional approach to combating workplace fatigue (mentioned above) does not consider all aspects of fatigue and have a single-layer defensive strategy in the workplace. A new, more comprehensive method to managing workplace fatigue risk is Fatigue Risk Management System (FRMS). The scientific theoretically baseline of FRMS is based on principle of knowledge in sleep science. Then, it is necessary to pay careful consideration to the dynamic of transient and cumulative sleep debt and recovery, the circadian biological clock, and the regulating influence of the circadian system on performance and alertness. Therefore, more new development in sleep sciences and human circadian rhythms providing stronger scientific basis for FRMS to manage fatigue risks in industrial settings is required.[4,12]

FRMS is composed of a number of essential layer defenses for monitoring and managing the risks posed to workplace safety by fatigue. This multiple layer defenses are a product of incorporation fatigue management within the general context of the Safety Management System (SMS). According to SMS, safety is comprised when a hazard is able to penetrate successfully from all layers of defense resulting to inducing a trajectory of incident opportunity. The strengthening individual layers and the appropriate selection of supplementary layers could increase the effectiveness of the Safety Management System.[4]

At both of them an accident or incident are considered as the final point of casual chain of events. The SMS processes are designed to address all types of risks, while FRMS are specifically designed to combat the risks related to workplace's fatigue. FRMS model was first suggested by Dawson and McCulloch. It includes a series of defensive layers that can be established at four points in combination with the potential event trajectory. Identifying and preventing fatigue-related accidents can be located at each of these points.[4,12]

According to this model, there are five defensive layers can be implemented to eliminate the probability of a fatigue-induced incident or accident in the workplace, including:

Level 1- Providing adequate sleep opportunity: The most important question in this level is;"how much sleep opportunity provided by a specific working time arrangement?". To minimize the likelihood of fatigue, the organization must be ensuring that sufficient sleep opportunities are provided for employees. This level addressed partially by the traditional approach

Level 2- Confirming that adequate sleep is obtained for employees to indicate fitness for duty: The employees must ask themselves; "have I had enough sleep recently to work safe?" The first control level is not always sufficient. It is possible for an employee to have an optimal work pattern, but to be too tired to work safely (e.g. did not get enough sleep during the resting period due to a familial activity). Therefore, assessing minimum sleep and maximum time awake in the 48-h period is a critical control factor in this level

Level 3- Detecting behavioral symptoms of fatigue: Even though two prior levels might be perfect, there is possibility that cumulative forms of fatigue impair performance and induce risk. Different factors such as individual differences in the sleep requirement, other sleep disorders, and idiopathic reasons might be responsible. This level helps individuals and organization to detect fatigue symptoms by a wide range of instrument from simple symptom checklists (e.g. Samn-Perelli Fatigue Checklist) to complex physiological testing

Level 4 and 5- Concerning with assessment and control of fatigue-related errors and incidents: Was fatigue a possible indicator of cognitive performance impairment, near miss, or incidents? These levels used to monitor the effectiveness of prior levels. Data driven from these steps identify any location in the workplace where FRMS activities were not sufficient to prevent fatigue resulting in an error, near miss, or incidents. Some of tools for data collection in level 4 including performance testing, field observations, and documented errors. The systematic incident investigation with respect to the possibility of fatigue as a causal or contributory factor should be involved in level 5. Data collection during the process is used to improve operational circumstances and to

continually update FRMS in the workplace that will better prevent future incidents.[4,24]

After identifying potential high risk areas in the workplace for fatigue induction, there are two possible approaches which can be used to either reduce or eliminate fatigue fatigue reduction) or mitigate effects of fatigue (fatigue proofing). Fatigue reduction strategy is related to the first three levels of FRMS that reduce likelihood that a fatigue worker enters or remains in the workplace. On the other hand, fatigue proofing refers to strategies that decrease the probability in which a fatigued worker operating in the workplace will make an error that leads to accident or injury. For example, lower risk tasks may be scheduled in times when fatigue risk is higher and more complex tasks in times when the risk of fatigue is lower.

The optimal management of fatigue-related risks requires that both of the fatigue reduction and fatigue proofing strategies to be implemented as complementary elements of an FRMS.[4,20,21,24]

In conclusion, workers' fatigue is a significant problem in modern industry, largely because of high demand jobs, long duty periods, disruption of circadian rhythms, and accumulative sleep debt that are common in many industries. The severity of problem and ways to deal with fatigue is very different in industries. The full understanding of circadian biologic clock, dynamics of transient and cumulative sleep loss, and recovery is required for effective management of workplace fatigue. It can be more investigated in a new field of sleep medicine called occupational sleep medicine. Occupational sleep medicine is concerned with maintaining best productivity and safety in the industrial settings. It is anticipated that new advances in the field of occupational sleep medicine will develop more valid and reliable instrument to measure fatigue and manage it properly in operational settings.

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